

STOVE BUILDER INTERNATIONAL INC.

TEST REPORT

SCOPE OF WORK

EPA EMISSIONS TESTING/1.4 SERIES (OSBURN 950, ESCAPE 1200, GATEWAY 1400, SOLUTION 1.4, SPARK II, FOX, DÉCO NANO, S250, HARMONY 1.4, HES140)/ WOOD FUEL ROOM HEATER

REPORT NUMBER

104473478MTL-001R1

TEST DATE(S)

11/17/20 - 11/20/20

ISSUE DATE

12/22/20

[REVISED DATE]

03/03/21

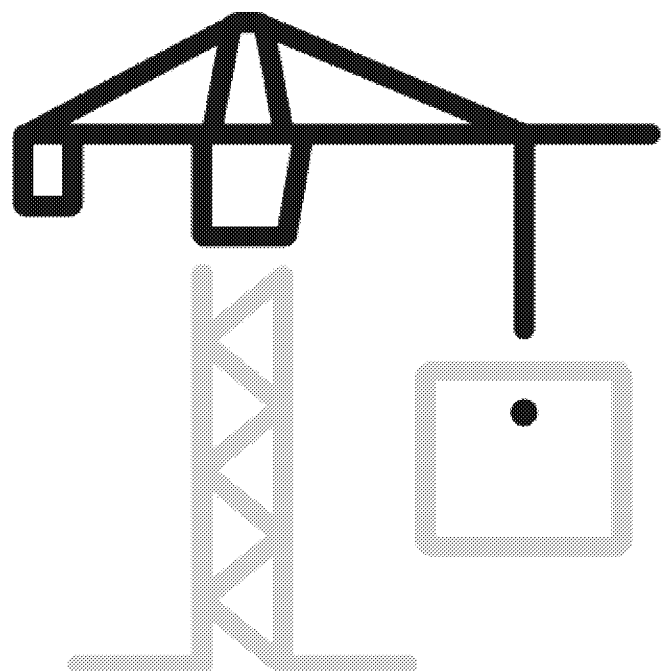
PAGES

30

DOCUMENT CONTROL NUMBER

GFT-OP-10c (05/10/17)

© 2017 INTERTEK



TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

REPORT ISSUED TO

STOVE BUILDER INTERNATIONAL, INC.

250 de Copenhague

ST-Augustin-de-Desmaures, Qc, G3A 2H3

SECTION 1

SCOPE

Intertek Testing Services NA (Intertek) has conducted testing for Stove Builder International Inc., on model Spark II Wood Burning Room Heater to evaluate all applicable performance requirements included in "Determination of particulate matter emissions from wood heaters." Spark II is a representative model of the 1.4 Series. This series includes the following models: Osburn 950, Escape 1200, Gateway 1400, Solution 1.4, Spark II, Fox, Déco Nano, S250, Harmony 1.4 and HES140. See PEV # 104473478MTL-002 for more details.

The test was conducted to determine if the unit is in accordance with U.S EPA requirements under EPA 40 CFR Part 60 "Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces". This evaluation was conducted on November 17th to November 20th, 2020. The following test methods were applicable:

ASTM E2515-11- Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel

ASTM E3053-17 - Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters using Cordwood Test Fuel. It is based on the ALT-125 send by EPA on February 28th, 2018.

CSA B415.1-10 - Performance Testing of Solid-Fuel-Burning Heating Appliances

Testing was performed by the undersigned at client's facility.

This report does not constitute certification of this product nor an opinion or endorsement by this laboratory.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

SECTION 2

SUMMARY OF TEST RESULTS

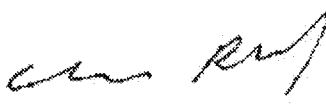

The appliance tests resulted in the following performance:

Particulate Emissions: 1.8 g/hr

Carbon Monoxide Emissions: 1.2 g/min

Heating Efficiency: 74% (Higher Heating Value Basis)

For INTERTEK B&C:

COMPLETED BY:	Claude Pelland, P.E. Manager B&C, Intertek, Quebec	REVIEWED BY:	Brian Ziegler Technical Team Leader - Hearth
TITLE:		TITLE:	
SIGNATURE:		SIGNATURE:	
DATE:	03/03/21	DATE:	03/24/21

aaa:bbb

SECTION 3

TEST METHOD(S)

The specimen was evaluated in accordance with the following:

ASTM E2515-11- Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel

ASTM E3053-17 - Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters using Cordwood Test Fuel. It is based on the ALT-125 send by EPA on February 28th, 2018.

CSA B415.1-10 - Performance Testing of Solid-Fuel-Burning Heating Appliances

SECTION 4

MATERIAL SOURCE

A sample was submitted to Intertek directly from the client. The sample was not independently selected for testing. The test unit was handed to the Intertek representative at client's facility in St-Augustin-de-Desmaures, Quebec. The unit was inspected upon receipt and found to be in good condition. The unit was set up following the manufacturer's instructions without difficulty.

Following assembly, the unit was placed on the test stand. Prior to beginning the emissions tests, the manufacturer operated the unit for a minimum of 50 hours at medium burn rates to break-in

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

the stove. The unit was found to be operating satisfactory during this break-in. The 50 plus hours of pre-burning were conducted from November 2nd to November 12th, 2020. The fuel used for the break-in process was beech cordwood. Table 1 shows the summary of the burn time in each test ran at medium burn rate; raw data is available on *Appendix F – Unit pre-burn documentation*.

Table 1 - Pre-burn time at medium burn rate summary

DATE	BURN CYCLE	DURATION (MIN)	LOAD TYPE (-)	FUEL ADDED (LBS)	MOISTURE (% DB)
2020-11-02	Preload	49	Kindling & SUF	8.09	16.0
	Condition	103	High fire	16.22	20.5
	Medium	410	Medium fire	19.52	20.7
2020-11-03	Preload	67	Kindling & SUF	8.12	14.5
	Condition	102	High fire	16.27	20.3
	Medium	430	Medium fire	19.50	19.8
2020-11-04	Preload	54	Kindling & SUF	8.12	17.1
	Condition	108	High fire	16.24	20.1
	Medium	370	Medium fire	19.47	21.3
2020-11-05	Preload	147	Kindling & SUF	8.11	16.2
	Condition	24	High fire	16.25	20.6
	Medium	72	Medium fire	19.53	19.8
2020-11-09	Preload	108	Kindling & SUF	8.12	14.7
	Condition	67	High fire	16.29	21.5
	Medium	380	Medium fire	19.52	20.4
2020-11-12	Preload	85	Kindling & SUF	8.13	17.3
	Condition	97	High fire	16.26	20.5
	Medium	510	Medium fire	19.51	19.1
Total		3183	minutes		
		53.05	hours		

* Only partial data is available on November 5th 2020 due to a power failure.

Following the pre-burn break-in process the unit was allowed to cool and ash and residue were removed from the firebox. The unit's chimney system and laboratory dilution tunnels were cleaned using standard wire brush chimney cleaning equipment on November 13th, 2020. On November 16th, 2020, the unit was set-up for testing.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

SECTION 5 EQUIPMENT

Equipment	INV Number	Calibration Due	MU
Floor scale	SBI-014	March 31, 2021	± 0.020 kg
DGM system 1	SBI-046	April 01, 2021	±2% F.S.
DGM System 2	SBI-047	April 06, 2021	±2% F.S.
Reference DGM	SBI-103	October 13, 2021	±2% F.S.
5 kg weight	SBI-190	October 02, 2023	±0.2 g
Temperature acquisition	SBI-197	November 03, 2021	±0.5°F
Pitot tube type S	SBI-204	December 20, 2020	±0.57 mps
Analytical scale	SBI-206	March 31, 2021	±0.08 mg
Table scale	SBI-222	March 31, 2021	±0.5 g
100 mg weight	SBI-237	October 09, 2023	±0.0025 mg
10 g weight	SBI-238	October 09, 2023	±0.012 mg
Hot wire anemometer	SBI-241	March 02, 2021	±0.15 m/s
Magnesense (tunnel)	SBI-254	July 17, 2021	±0.00015" H ₂ O
Magnesense (draft)	SBI-247	July 17, 2021	±0.00015" H ₂ O
DGM system 3	SBI-290	April 05, 2021	±2% F.S.
Pressure transmitter	SBI-294	July 17, 2021	±9.5e-003 psi
Pressure transmitter	SBI-297	July 17, 2021	±9.5e-003 psi
Vacuum transmitter	SBI-301	July 27, 2021	±6.1e-003 in.HG
Vacuum transmitter	SBI-305	July 27, 2021	±5.8e-003 in.HG
Relative humidity temperature meter	SBI-212	September 10, 2021	±3%
200 g weight	SBI-312	October 09, 2023	±0.06 mg
Barometer	SBI-331	October 01, 2022	±0.62mb/hPa
Moisture Content Standard	SBI-153	October 28, 2021	±0.2%
Multimeter	SBI-194	November 24, 2021	±1% Ω
Thermometer Calibrator	SBI-096	May 25, 2021	±0.5°F

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

SECTION 6

LIST OF OFFICIAL OBSERVERS

NAME	COMPANY
Guillaume Thibodeau-Fortin	Stove Builder International inc.
Gabrielle Santerre	Stove Builder International inc.
Claude Pelland, P.E.	Intertek B&C

SECTION 7

TEST PROCEDURE

From November 17th to November 20th, 2020, the unit was tested for EPA emissions. For Wood stoves, the test was conducted in accordance with ASTM E3053-17 and ASTM E2515-11. The fuel used for the test run was beech cordwood.

The applicable EPA regulatory limits are:

Step 2 – 2020 – 2.0 grams per hour with crib, 2.5 grams per hour with cordwood.

MANUFACTURER LOADING PROCEDURE

Kindling and SUF (8 lbs) - Split the start-up fuel log into 6 pieces. Put 2 kindling pieces on the brick in an orientation that points to the left (10-15 degrees from North-South). Then, put 2 start-up fuel pieces with two kindling between them in a North-South orientation. Make two more rows in the same way, alternating with a left pointed and North-South orientation. Finally, put the remaining kindling (4-5) in a left pointed orientation. Leave a little space between each piece.

The kindling is made of between 12-13 finely split piece of wood that are 10% of moisture content. Place crumbled newspaper on top of the kindling (5 full sheets). Light up the paper and let the door ajar at 90° until the flue temperature reaches 225°F, then close the door. The fan is always OFF.

Low&Medium Pre-load (high fire) (16.2 lbs) - When there is a coal bed of 1.65 lbs left, break ashes and level coal bed, then add pre-load (five pieces). Place the 3 smallest pieces in the bottom in a North-South orientation. They should touch the rear bricks and be 1 ½ inch apart from each other. Then, put the largest piece on top of the left and middle pieces in a right pointed orientation. Put the last piece on top of the middle and right piece in a right pointed orientation. There should be at least 2 inches between the two top pieces. Close the door immediately and let burn until the weight is down to target.

When the average stove temperature gets to 440°F, slightly level the coal bed. There should be approximately 3.9 lb of coal bed.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Low fire load (19.5 lbs) - Place the smallest piece on the coal bed in the middle of the stove in a North-South orientation. Place the other two smaller ones on each side at approximately ¼" of the side bricks to leave as much space as possible between the pieces. Then, put the largest piece on top of the left and middle pieces in a right pointed orientation. Put the last piece on top of the middle and right pieces in a right pointed orientation. There should be at least 2 inches between the two top pieces. The bottom pieces should be as close as possible to the inner air channel. Let the door ajar for 4 minutes and then close the door with the primary air control fully open. When the oxygen falls below 7%, close the primary air control to 90% (2.75 on the marking on the ash shelf). If the oxygen continues to drop, continue to close the primary air control to 80% (2.5 on the ash shelf). If the oxygen goes above 9.5%, open the primary to 100%. The goal is to keep the oxygen between 7 and 8%. Start to close slowly the primary air control at 14 minutes, so that at 16 min (15 min or 15 % as per E3053 clause 8.6.7 plus loading time of 1 min as per clause 8.6.5), the primary air control is completely closed. Start the fan at minimum speed at 60 minutes.

Medium fire load (19.5 lbs) - Same as for low fire load, but the primary air inlet is open of 23/64 inch at the end of the 16 minutes run time. On the ash shelf, the opening is 1 5/8 inch from de fully closed position. Start the fan at minimum speed at 30 minutes.

High fire load (16 lbs) – When there is a coal bed of 1.65 lbs left, break ashes and level coal bed, then add the load (four pieces). Put the largest piece and one of the medium pieces centered at the back of the combustion chamber (they should touch the rear bricks). Put the two last pieces in a right pointed orientation on top of the first two pieces. There should be at least 2 inches between the two bottom pieces and between the two top pieces. Close the door immediately after loading. Start the fan at maximum speed at 15 minutes. Stop the test when 90% of the high fire load has been consumed.

TEST SET-UP DESCRIPTON

A 6" flue is connected to a standard 6" diameter vertical single wall pipe and insulated chimney system was installed to 15' above floor level. The single wall pipe extended to 8 feet above the floor and insulated chimney extended the remaining height.

AIR SUPPLY SYSTEM

Combustion air enters at the bottom of the heater, which is directed to the firebox. All gases exit through the 6" flue located on top of the heater.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

TEST FUEL PROPERTIES

The species of fuel used was beech. The fuel was split cordwood of nominal length of 16 inches \pm 1 inch. The fuel was dried in air to an average moisture content between 18% and 28% on a dry basis. Cordwood fuel was loaded in a North-South orientation into the firebox per manufacturer's instructions.

SAMPLING LOCATIONS

Particulate samples are collected from the dilution tunnel at point 20 feet from the tunnel entrance. The tunnel has two elbows and two mixing baffles in the system ahead of the sampling section. (See Figure 3.) The sampling section is a continuous 13-foot section of 8-inch diameter pipe straight over its entire length. Tunnel velocity pressure is determined by a type "S" Pitot tube located 100 inches from the beginning of the sampling section. The dry bulb thermocouple is located on the pitot tube. Tunnel samplers are located 48 inches downstream of the Pitot tube and 36 inches upstream from the end of this section. (See Figure 1.)

Stack gas samples are collected from the steel chimney section 8 feet \pm 6 inches above the scale platform.

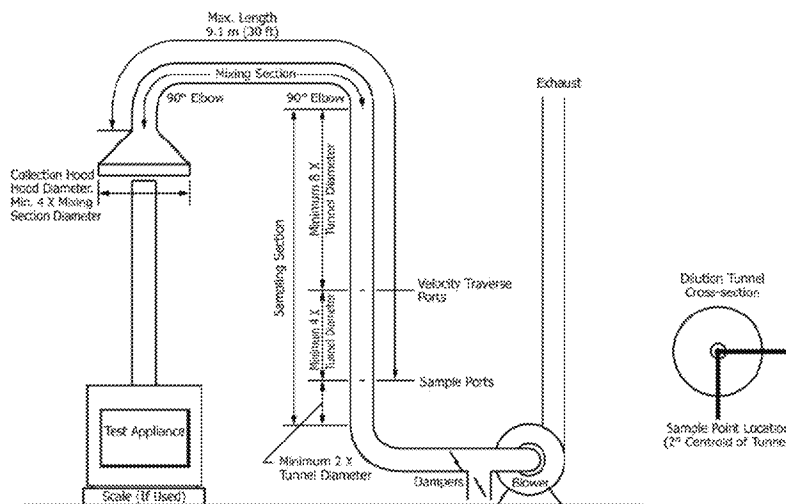


Figure 1 - Dilution tunnel

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

SAMPLING METHODS

PARTICULATE SAMPLING

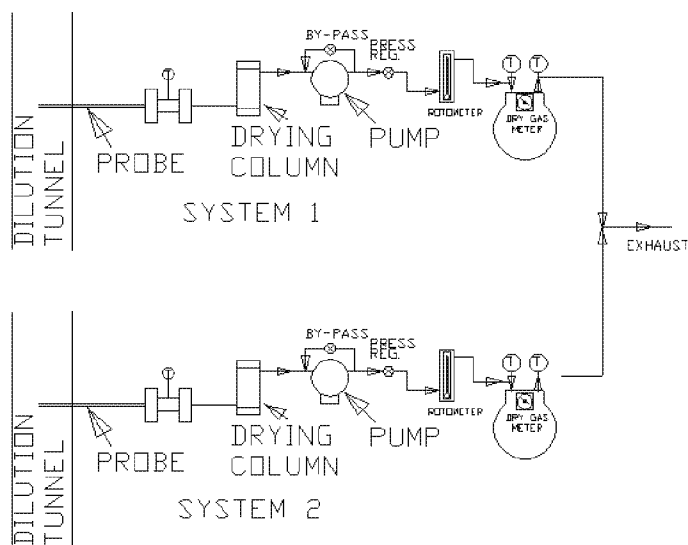


Figure 2 - Stock gas sample train

Particulates were sampled in strict accordance with ASTM E2515-2011. Schematic is presented on Figure 2. This method uses two identical sampling systems with Gelman A/E 61631 binder free, 47-mm diameter filters. The dryers used in the sample systems are filled with "Drierite" before each test run. In order to measure first-hour emissions rates, a third filter set is prepared at one hour into the test run, the filter sets are changed in one of the two sample trains. The two filter sets used for this train are analysed individually to determine the first hour and total emissions rate.

At the conclusion of each test program the dry gas meters are checked against our standard dry gas meter. Three runs are made on each dry gas meter used during the test program. The average calibration factors obtained are then compared with the six-month calibration factor and, if within 5%, the six-month factor is used to calculate standard volumes. Results of this calibration are contained in Appendix E.

An integral part of the post-test calibration procedure is a leak check of the pressure side by plugging the system exhaust and pressurizing the system to 10" W.C. The system is judged to be leak free if it retains the pressure for at least 10 minutes.

The standard dry gas meter is calibrated every 6 months using a Spirometer designed by the EPA Emissions Measurement Branch. The process involves sampling the train operation for 1 cubic foot of volume. With readings made to .001 ft³, the resolution is .1%, giving an accuracy higher than the ±2% required by the standard.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

STACK SAMPLE ROTAMETER

The stack sample rotameter is checked by running three tests at each flow rate used during the test program. The flow rate is checked by running the rotameter in series with one of the dry gas meters for 10 minutes with the rotameter at a constant setting. The dry gas meter volume measured is then corrected to standard temperature and pressure conditions. The flow rate determined is then used to calculate actual sampled volumes.

GAS ANALYZERS

The continuous analyzers are zeroed and spanned before each test with appropriate gases. A mid-scale multi-component calibration gas is then analyzed (values are recorded). At the conclusion of a test, the instruments are checked again with zero, span and calibration gases (values are recorded only). The drift in each meter is then calculated and must not exceed 5% of the scale used for the test.

At the conclusion of each unit test program, a three-point calibration check is made. This calibration check must meet accuracy requirements of the applicable standards. Consistent deviations between analyser readings and calibration gas concentrations are used to correct data before computer processing. Data is also corrected for interferences as prescribed by the instrument manufacturer's instructions.

TEST METHOD PROCEDURES**LEAK CHECK PROCEDURES**

Before and after each test, each sample train is tested for leaks. Leakage rates are measured and must not exceed 0.02 CFM or 4% of the sampling rate. Leak checks are performed checking the entire sampling train, not just the dry gas meters. Pre-test and post-test leak checks are conducted with a vacuum of 10 inches of mercury. Vacuum is monitored during each test and the highest vacuum reached is then used for the post-test vacuum value. If leakage limits are not met, the test run is rejected. During, these tests the vacuum was typically less than 2 inches of mercury. Thus, leakage rates reported are expected to be much higher than actual leakage during the tests.

TUNNEL VELOCITY/FLOW MEASUREMENT

The tunnel velocity is calculated from a center point Pitot tube signal multiplied by an adjustment factor. This factor is determined by a traverse of the tunnel as prescribed in EPA Method 1. Final tunnel velocities and flow rates are calculated from EPA Method 2, Equation 6.9 and 6.10. (Tunnel cross sectional area is the average from both lines of traverse.)

Pitot tubes are cleaned before each test and leak checks are conducted after each test.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

PM SAMPLING PROPORTIONALITY

Proportionality was calculated in accordance with ASTM E2515-11. The data and results are included in Appendix B.

DEVIATIONS FROM STANDARD METHOD:

The following deviations were requested by EPA on ALT-125:

Changes to ASTM E3053-17 are:

1. Coal bed conditions prior to loading test fuel: The coal bed should be a level plane without valleys or ridges for all test runs in the high fire, low and medium burn rate categories.

Changes to ASTM E2515-11 must be as followed:

1. The filter temperature must be maintained between 80 and 90 Degrees F during testing.
2. Filters must be weighed in pairs to reduce weighing error propagation.
3. Sample filters must be Pall TX-40 or equivalent Teflon coated glass fiber, and of 47 mm, 90mm, 100mm or 110mm in diameter.
4. Only one point is allowed outside the +/- 10% proportionality range per test run.

SECTION 8

TEST CALCULATIONS

Weight of test fuel load, dry basis

ASTM E3053

$$M_{FLdb} = \sum \{ (M_{FLnwb}) (100) / (100 + MC_{FLn}) \}$$

where:

- M_{FLdb} = weight of test fuel load, dry basis, lb (kg);
 M_{FLnwb} = weight of each test fuel piece, n , in test fuel load per 8.4.1, wet basis, lb (kg);
 MC_{FLn} = average fuel moisture of test fuel piece, n , in test fuel load, % dry basis; and
 n = individual test fuel pieces that comprise the test fuel load, as applicable.

Weighted Average Determination

ASTM E3053

$$V_{iWA} = 0.4(V_{iLAve}) + 0.4(V_{iMAve}) + 0.2(V_{iHAve})$$

where:

- V_{iWA} = Weighted average for variable i ;

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

- V_i = Test result variable (Particulate Matter: g/h, g/kg, lb/MMBtu; % Overall Efficiency: HHV, LHV; Carbon Monoxide: g/h, etc.)
- V_{iLAve} = Arithmetic average for variable V_i for all test runs (except per 8.6.13 or 8.9) that are included in the low fire burn rate category
- V_{iMAve} = Arithmetic average for variable V_i for all test runs (except per 8.6.13 or 8.9) that are included in the medium fire burn rate category;
- V_{iHAve} = Arithmetic average for variable V_i for all test runs (except per 8.9) that are included in the high fire burn rate category.

NOMENCLATURE FOR ASTM E2515:

- A = Cross-sectional area of tunnel m² (ft²).
- B_{ws} = Water vapor in the gas stream, proportion by volume (assumed to be 0.02 (2.0 %)).
- C_p = Pitot tube coefficient, dimensionless (assigned a value of 0.99).
- C_r = Concentration of particulate matter room air, dry basis, corrected to standard conditions, g/dscm (gr/dscf) (mg/dscf).
- C_s = Concentration of particulate matter in tunnel gas, dry basis, corrected to standard conditions, g/dscm (gr/dscf) (mg/dscf).
- E_T = Total particulate emissions, g.
- F_p = Adjustment factor for center of tunnel pitot tube placement.
 $F_p = V_{strav}/V_{scent}$
- K_p = Pitot Tube Constant, $34.97 \frac{m}{sec} \left[\frac{\left(\frac{g}{g} \cdot mole \right) (mm\ Hg)}{(K)(mm\ water)} \right]^{\frac{1}{2}}$
or
= Pitot Tube Constant, $85.49 \frac{ft}{sec} \left[\frac{\left(\frac{lb}{lb} \cdot mole \right) (in\ Hg)}{(R)(in\ water)} \right]^{\frac{1}{2}}$
- L_a = Maximum acceptable leakage rate for either a pretest or post-test leak-check, equal to 0.0003 m³/min (0.010 cfm) or 4 % of the average sampling rate, whichever is less.
- L_p = Leakage rate observed during the post-test leak-check, m³/min (cfm).
- m_p = mass of particulate from probe, mg.
- m_f = mass of particulate from filters, mg.
- m_g = mass of particulate from filter gaskets, mg.
- m_r = mass of particulate from the filter, filter gasket, and probe assembly from the room air blank filter holder assembly, mg.
- m_n = Total amount of particulate matter collected, mg.
- M_s = the dilution tunnel dry gas molecular weight (may be assumed to be 29 g/g mole (lb/lb mole)).
- P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).
- P_g = Static Pressure in the tunnel (in. water).
- P_R = Percent of proportional sampling rate.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

P_s = Absolute average gas static pressure in dilution tunnel, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

Q_{std} = Average gas flow rate in dilution tunnel.

$$Q_{std} = 60 (1 - B_{ws}) V_s A [T_{std} P_s / T_s P_{std}]$$

dscm/min (dscf/min).

T_m = Absolute average dry gas meter temperature, K (R).

T_{mi} = Absolute average dry gas meter temperature during each 10-min interval, i , of the test run.

$$T_{mi} = (T_{mi(b)} + T_{mi(e)})/2$$

where:

$T_{mi(b)}$ = Absolute dry gas meter temperature at the beginning of each 10-min test interval, i , of the test run, K (R), and

$T_{mi(e)}$ = Absolute dry gas meter temperature at the end of each 10-min test interval, i , of the test run, K (R).

T_s = Absolute average gas temperature in the dilution tunnel, K (R).

T_{si} = Absolute average gas temperature in the dilution tunnel during each 10-min interval, i , of the test run, K (R).

$$T_{si} = (T_{si(b)} + T_{mi(e)})/2$$

where:

$T_{si(b)}$ = Absolute gas temperature in the dilution tunnel at the beginning of each 10-min test interval, i , of the test run, K (R), and

$T_{si(e)}$ = Absolute gas temperature in the dilution tunnel at the end of each 10-min test interval, i , of the test run, K (R).

V_m = Volume of gas sample as measured by dry gas meter, dcm (dcf).

V_{mc} = Volume of gas sampled corrected for the post test leak rate, dcm (dcf).

V_{mi} = Volume of gas sample as measured by dry gas meter during each 10-min interval, i , of the test run, dcm.

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions.

$$V_{m(std)} = K_1 V_m Y [(P_{bar} + (\Delta H/13.6))/T_m]$$

where:

K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units.

$$V_{m(std)} = K_1 V_{mc} Y [(P_{bar} + (\Delta H/13.6))/T_m]$$

where:

V_{mc} = $V_m - (L_p - L_a)u$

V_{mr} = Volume of room air sample as measured by dry gas meter, dcm (dcf), and

$V_{mr(std)}$ = Volume of room air sample measured by the dry gas meter, corrected to standard conditions.

$$V_{m(std)} = K_1 V_{mr} Y [(P_{bar} + (\Delta H/13.6))/T_m]$$

Where:

K_1 = 0.3855 K/mm Hg for SI units and = 17.64 R/in. Hg for inch-pound units, and

V_s = Average gas velocity in the dilution tunnel.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

- $V_s = F_p K_p C_p (V \Delta P_{avg})(V(T_s/P_s M_s))$
- V_{si} = Average gas velocity in dilution tunnel during each 10-min interval, i, of the test run.
- $V_{si} = F_p K_p C_p (V \Delta P_i)(V(T_{si}/P_s M_s))$
- V_{scent} = Average gas velocity at the center of the dilution tunnel calculated after the Pitot tube traverse.
- V_{strav} = Average gas velocity calculated after the multipoint Pitot traverse.
- Y = Dry gas meter calibration factor.
- ΔH = Average pressure at the outlet of the dry gas meter or the average differential pressure across the orifice meter, if used, mm water (in. water).
- ΔP_{avg} = Average velocity pressure in the dilution tunnel, mm water (in. water).
- ΔP_i = Velocity pressure in the dilution tunnel as measured with the Pitot tube during each 10-min interval, i, of the test run.

$$\Delta P_i = (\Delta P_{i(b)} + \Delta P_{i(e)})/2$$

where:

- $\Delta P_{i(b)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the beginning of each 10-min interval, i, of the test run, mm water (in. water), and
- $\Delta P_{i(e)}$ = Velocity pressure in the dilution tunnel as measured with the Pitot tube at the end of each 10-min interval, i, of the test run, mm water (in. water).
- θ = Total sampling time, min.
- 10 = ten min, length of first sampling period.
- 13.6 = Specific gravity of mercury.
- 100 = Conversion to percent.

TOTAL PARTICULATE WEIGHT – ASTM E2515

$$M_n = m_p + m_f + m_g$$

PARTICULATE CONCENTRATION – ASTM E2515

$$C_s = K_2(m_n/V_{m(std)}) \text{ g/dscm (g/dscf)}$$

where:

$$K_2 = 0.001 \text{ g/mg}$$

TOTAL PARTICULATE EMISSIONS (g) – ASTM E2515

$$E_T = (C_s - C_r)Q_{std}\theta$$

PROPORTIONAL RATE VARIATION (%) – ASTM E2515

$$PR = [\theta(V_{mi} V_s T_m T_{si}) / (10(V_m V_{si} T_s T_{mi}))] \times 100$$

MEASUREMENT OF UNCERTAINTY – ASTM E2515

$$MU_{weighing} = \sqrt{0.1^2} \cdot X$$

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

GENERAL FORMULA – ASTM E2515

$$uY = \sqrt{((\delta Y/\delta x_1) \times u_1)^2 + \dots + ((\delta Y/\delta x_n) \times u_n)^2}$$

Where:

$\delta Y/\delta x_i$ = Partial derivative of the combining formula with respect to individual measurement x_i ,

u_i = is the uncertainty associated with that measurement.

TOTAL PARTICULATE EMISSIONS – ASTM E2515

$$E_T = (c_s - c_r) Q_{std} \theta$$

where:

c_s = sample filter catch/(sample flow rate x test duration), g/dscf,

c_r = room background filter catch/(sample flow x sampling time), g/dscf,

Q_{std} = average dilution tunnel flow rate, dscf/min, and

θ = sampling time, minutes.

MU OF c_s

$$c_s = F_c/(Q_{sample} \times \theta) = 0.025/(0.25 \times 180) = 0.0005555$$

$$\delta c_s/\delta F_c = 1/Q_{sample} \cdot \theta = 1/0.25 \cdot 180 = 0.0222$$

$$\delta c_s/\delta Q_{sample} = -F_c/Q_{sample}^2 \cdot \theta = -0.025/0.25^2 \cdot 180 = -0.00222$$

$$\delta c_s/\delta \theta = -F_c/Q_{sample} \cdot \theta^2 = -0.025/0.25 \cdot 180^2 = -0.000003$$

$$MU_{c_s} = \sqrt{(0.00027 \cdot 0.0222)^2 + (0.0025 \cdot -0.00222)^2}$$

$$\sqrt{+ (0.1 \cdot -0.000003)^2} = 0.0000091g$$

Thus, c_s would be 0.555 mg/dscf \pm 0.0081 mg/dscf at 95% confidence level.

MU OF c_r

$$c_r = BG_c/(Q_{BG} \times \theta) = 0.002/(0.15 \times 180) = 0.000074$$

$$\delta c_r/\delta BG_c = 1/Q_{BG} \cdot \theta = 1/0.15 \cdot 180 = 0.03704$$

$$\delta c_r/\delta Q_{BG} = -BG_c/Q_{BG}^2 \cdot \theta = -0.002/0.15^2 \cdot 180 = -0.0004938$$

$$\delta c_r/\delta \theta = -BG_c/Q_{BG} \cdot \theta^2 = -0.002/0.15 \cdot 180^2 = -0.0000004$$

$$MU_{c_r} = \sqrt{(0.00027 \cdot 0.03704)^2 + (0.0015 \cdot -0.0004938)^2}$$

$$\sqrt{+ (0.1 \cdot -0.0000004)^2} = 0.00001g$$

Thus, c_r would be 0.074 mg/dscf \pm 0.01 mg/dscf at 95% confidence level.

E_T AND MU_{ET}

$$E_T = (c_s - c_r) Q_{std} \theta = (0.000555 - 0.000074) \times 150 \times 180 = 13.00g$$

$$\delta E_T/\delta c_s = Q_{std} \cdot \theta = 150 \cdot 180 = 27,000$$

$$\delta E_T/\delta c_r = Q_{std} \cdot \theta = 150 \cdot 180 = 27,000$$

$$\delta E_T/\delta Q_{std} = c_s \cdot \theta - c_r \cdot \theta = 0.000555 \cdot 180 - 0.000074 \cdot 180 = 0.08667$$

$$\delta E_T/\delta \theta = c_s \cdot Q_{std} - c_r \cdot Q_{std} = 0.000555 \cdot 180 - 0.000074 \cdot 180 = 0.07222$$

$$MU_{ET} = \sqrt{(27,000 \cdot 0.0000081)^2 + (27,000 \cdot 0.00001)^2 (0.08667 \cdot 3)^2}$$

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

$$v + (0.07222 \cdot 0.1)^2 = 0.436$$

Thus the result in this example would be:

ET = 13.00g ± 0.44 g at a 95% confidence level.

EFFICIENCY – CSA B415.1

The change in enthalpy of the circulating air shall be calculated using the moisture content and temperature rise of the circulating air, as follows:

$$\Delta h = \Delta t (1.006 + 1.84x)$$

Where:

Δh = change in enthalpy, kJ/kg

Δt = temperature rise, °C

1.006 = specific heat of air, kJ/kg °C

1.84 = specific heat of water vapor, kJ/kg °C

x = humidity ratio, kg/kg

The equivalent duct diameter shall be calculated as follows:

$$ED = 2HW/H+W$$

Where:

ED = equivalent duct diameter

H = duct height, m

W = duct width, m

The air flow velocity shall be calculated as follows:

$$V = F_p \times C_p \times 34.97 \times \sqrt{T/28.56(P_{\text{baro}} + P_s)}$$

where

V = velocity, m/s

F_p = Pitot tube calibration factor determined from vane anemometer measurements

C_p = Pitot factor

= 0.99 for a standard Pitot tube or as determined by calibration for a Type S Pitot tube

34.97 = Pitot tube constant

Note: The Pitot tube constant is determined on the basis of the following units:

m/s [g/g mole (mm Hg)/(K)(mm H₂O)]^{0.5}

ΔP = velocity pressure, mm H₂O

T = temperature, K

28.56 = molecular weight of air

P_{Baro} = barometric pressure, mm Hg

P_s = duct static pressure, mm Hg

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

The mass flow rate shall be calculated as follows:

$$m = 3600VAp$$

where:

m = mass flow rate, kg/h

V = air flow velocity, m/s

3600 = number of seconds per hour

A = duct cross-sectional area, m²

p = density of air at standard temperature and pressure (use 1.204 kg/m³)

The rate of heat release into the circulating air shall be calculated using the air flow and change in enthalpy, as follows:

$$\Delta e = \Delta h \times m$$

Where:

Δe = rate of heat release into the circulating air, kJ/h

Δh = change in enthalpy of the circulating air, kJ/kg

m = mass air flow rate, kg/h

The heat output over any time interval shall be calculated as the sum of the heat released over each measurement time interval, as follows:

$$E_t = \sum(\Delta e \times i) \text{ for } i = t_1 \text{ to } t_2$$

Where:

E_t = delivered heat output over any time interval $t_2 - t_1$, kJ

i = time interval for each measurement, h

The average heat output rate over any time interval shall be calculated as follows:

$$e_t = E_t / t$$

where

e_t = average heat output, kJ/h

t = time interval over which the average output is desired, h

The total heat output during the burn shall be calculated as the sum of all the heat outputs over each time interval, as follows:

$$E_d = \sum(E_t) \text{ for } t = t_0 \text{ to } t_{\text{final}}$$

Where:

E_d = heat output over a burn, kJ/h (Btu/h)

E_t = heat output during each time interval, kJ/h (Btu/h)

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

The efficiency shall be calculated as the total heat output divided by the total energy input, expressed as a percentage as follows:

$$\text{Efficiency, \%} = 100 \times E_d / I$$

Where:

E_d = total heat output of the appliance over the test period, kJ/kg

I = input energy (fuel calorific value as-fired times weight of fuel charge), kJ/kg (Btu/lb)

SECTION 9

TEST SPECIMEN DESCRIPTION

The model from the 1.4 Series (Spark II) Wood Fuel Room Heater is constructed of sheet steel. The outer dimensions are 27 9/16-inches deep, 28 9/16-inches high, and 18 1/2-inches wide. The unit has a door located on the front with a viewing glass.

FIREBOX CALCULATION

The model from the 1.4 Series (Spark II) has a usable firebox volume (UFV) of 1.55 cubic foot. Schematic of the firebox dimensions is presented on Figure 3. Please note that the fuel can't be stacked any higher due to the secondary air tubes being at the top of the combustion chamber.

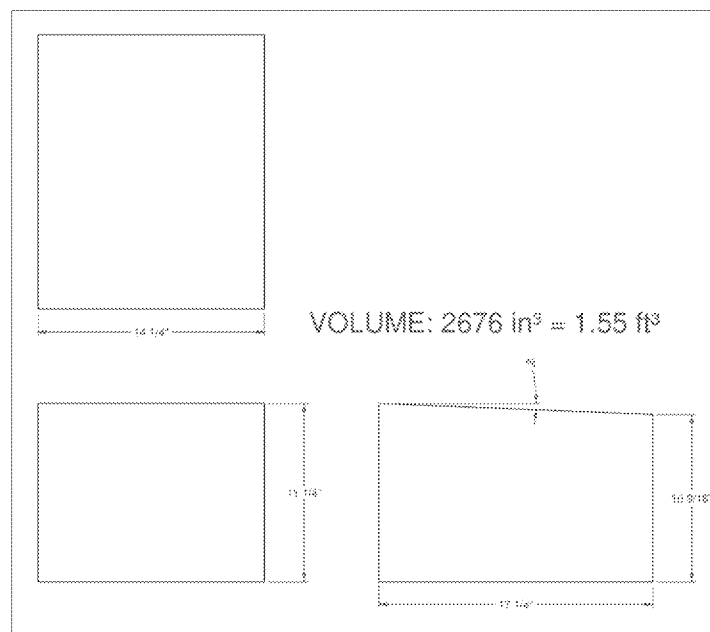


Figure 3 - Schematic of firebox volume

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Firebox volume calculation is presented below:

$$UFV = \frac{(10.563 + 11.25)}{2} \times 14.25 \times 17.25 = 2680.89 \text{ in}^3$$

$$UFV = \frac{2680.89}{12^3} = 1.55 \text{ ft}^3$$

SECTION 10

TEST RESULTS

GENERAL DISCUSSION:

All runs have been found appropriate and all runs below have been validated and found compliant. One anomaly occurred with Run 1. Run 1 was the first attempt of low burn rate. The combustion went faster than expected, but was found to be compliant, respecting the criterion of 1.15 kg/h maximum. The combustion was barely present at the beginning causing higher emission rate. When dry, the test fuel pieces burn hotter than expected, which gave a higher-than-expected burn rate. A second low burn rate test was performed on Run 3 and burned as expected. All burn rate categories were achieved, and all data were used in the calculation of the weighted average.

All test fuel pieces have been positioned in a North-South orientation as per the manufacturer's written instructions. All test fuel pieces were split to meet individual and total load weight range for the firebox. Test fuel pieces were split in order to preserve the bark. In the area without bark, splitting was done to represent the random shape of the wood as it can be found in a standard cord of wood. No test fuel pieces were voluntary squared.

Filters were not altered by the gasket in all runs. No negative weight was found on probes or filters.

DESCRIPTION OF TEST RUNS:

RUN #1 (November 17th, 2020) - Air control set fully closed, burn time was 398.5 minutes with a category Low burn rate 1.11 kg/hr. The door was left ajar for 4 minutes, and then closed. The air control was opened for 15 minutes after loading time, and then set at the lowest burn rate (fully closed). The fan was turned on at low speed at 60 minutes.

RUN #2 (November 18th, 2020) - Air control set at the medium burn rate (1 5/8 inch from fully closed position on ash shelf), burn time was 445.25 minutes with a category "Medium burn rate" of 0.99 kg/hr. Let the door ajar for 3 min and 45 sec, and then closed. The air control was opened for 15 minutes after loading time and then set at the targeted burn rate 1 5/8 inch from fully closed position). The fan was turned on at medium speed at 30 minutes. At 2h 37min 30sec from the start, the door was open for 30 sec and the remaining fuel was adjusted as per clause 8.6.8.2 of ASTM E3053-17. More than 60% of the test fuel load was consumed and the burn rate was smaller than 1% of the test fuel load weight on a 10 min period. Pictures are presented on

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Appendix H. With a medium burn rate having a smaller dry burn rate than the low burn rate, a second attempt of low burn rate was performed.

RUN #3 (November 19th, 2020) - Air control set fully closed, burn time was 480 minutes with a category Low burn rate 0.91 kg/hr. The door was left ajar for 4 min 30 sec, and then closed. The air control was opened for 15 minutes after loading time, and then set at the lowest burn rate (fully closed). The fan was turned on at low speed at 45 minutes. At 6h 3min 30 sec from the start, the door was open for 30 sec and the remaining fuel was adjusted as per clause 8.6.8.2 of ASTM E3053-17. More than 60% of the test fuel load was consumed and the burn rate was smaller than 1% of the test fuel load weight on a 10 min period. Pictures are presented on *Appendix H*.

RUN #4 (November 20th, 2020) - Air control set fully opened, burn time was 205 minutes with a category High burn rate 2.26 kg/hr. Burn time without the cold start was 160 minutes. The door was opened for 3 minutes after kindling was ignited, then closed. Loading occurred at 44min 10 sec. Door was open for 2 minutes. The air control was fully opened. The fan was started at full speed at 7 minutes. The test run ended when 90 % \pm 1% of the test full load was consumed.

RESULT TABLES:

Table 2 to Table 8 present the results of the evaluation. On section 14, Table 9 to Table 12 present the results as per the adjunct summary sheet of ASTM E3053.

Table 2 - EMISSION RESULTS

#	TEST DATE	BURN RATES (kg/hr) (Dry)	PM EMISSION RATE (g/hr)	1 ST HOUR EMISSIONS (g)	CO EMISSION RATE (g/hr)	CO EMISSION RATE (g/min)	HEATING EFF. (% HHV)
1	2020-11-17	1.1	2.21	10.6	74	1.2	75%
2	2020-11-18	0.99	1.61	9.08	74	1.2	73%
3	2020-11-19	0.91	1.22	6.82	53	0.9	74%
4	2020-11-20	2.3	2.22	4.46	96	1.6	73%

Table 3 - FUEL DATA SUMMARY

#	KINDLING WEIGHT (LBS)	KINDLING MC (%DB)	SU FUEL WEIGHT (LBS)	SU FUEL MC (%DB)	HIGH WEIGHT (LBS)	HIGH MC (%DB)	LOW/MED WEIGHT (LBS)	LOW/MED MC (%DB)
1	3.24	10	4.69	22.6	16.22	19.5	19.50	20.2
2	3.23	10	4.80	23.6	16.24	21.3	19.48	19.5
3	3.20	10	4.81	23.4	16.21	21.0	19.48	20.3
4	3.15	10	4.69	21.1	15.95	19.8	NA	NA

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Table 4 - TEST LAB CONDITIONS

#	AMB. TEMP. (°F) before	AMB. TEMP. (°F) after	PRESSURE (In. Hg) before	PRESSURE (In. Hg) after	R.H.% % before	R.H.% %% after	AIR VEL. (Ft/min) before	AIR VEL. (Ft/min) after
1	82.7	74.6	29.45	29.60	19.8	19.5	0	0
2	80.7	83.0	79.95	30.00	14.6	12.7	0	0
3	75.3	82.6	29.95	29.80	13.9	12.5	0	0
4	67.9	69.6	29.70	26.65	25.9	26.2	0	0

Table 5 - DILUTION TUNNEL

#	BURN TIME (min)	TUNNEL VELOCITY (ft/sec)	VOLUMETRIC FLOW RATE (dscf/min)	TUNNEL AVE. TEMP. (°F)	SAMPLE VOLUME (DSCF)		PARTICULATE CATCH (MG)	
					1	2	1	2
1	399	17.17	335.13	88	0.124	0.125	5.4	5.5
2	445	16.98	337.36	86	0.127	0.128	4.6	4.4
3	480	16.70	332.25	84	0.126	0.128	3.9	3.6
4	205	16.63	323.90	92	0.121	0.122	2.8	2.9

Table 6 - DILUTION TUNNEL PRECISION

#	SAMPLE RATIOS (-)		TOTAL EMISSIONS (g)		DEVIATION %	DEVIATION g/kg
	Train 1	Train 2	Train 1	Train 2		
1	2707	2675	14.618	14.710	0.3%	0.01
2	2663	2634	12.248	11.588	2.8%	0.09
3	2629	2596	10.251	9.345	4.6%	0.12
4	2668	2653	7.471	7.693	1.5%	0.03

Table 7 - GENERAL SUMMARY

#	BURN RATE (kg/hr)(Dry)	CHANGE IN SURFACE TEMP. (°F)	INITIAL DRAFT (in. wc)	RUN TIME (min)	AVERAGE DRAFT (in. wc)
1	1.1	159	0.048	398.5	0.041
2	0.99	210	0.050	445.25	0.042
3	0.91	196	0.052	480	0.041
4	2.3	214	0.000	205	0.064

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Table 8 - CSA B415.1-10 SUMMARY

BURN RATE (kg/hr)(Dry)	CO EMISSIONS (g/min)	HEATING EFFICIENCY (% HHV)	HEATING EFFICIENCY (% LHV)	HEAT OUTPUT (Btu/hr)
Low - 0.91	0.9	74	80	12,100
Low - 1.1	1.2	75	80	14,800
Medium - 0.99	1.2	73	79	13,000
High - 2.3	1.6	73	79	26,700

Table 9 - WEIGHTED AVERAGE CALCULATION

#	CAT	(E) PM EMISSION RATE (g/hr)	(CO) EMISSION RATE (g/hr)	HEAT OUTPUT Btu/hr	EFF. (% HHV)	EFF. (% LHV)	(K) Weight ing Factor	(KxE) g/hr	(KxCO) g/hr	(KxCO) g/min	(K x HHV)	(K x LHV)
3	L	1.22	53	12,100	74	80	20%*	0.24	10.6	0.18	14.9	15.9
1	L	2.21	74	14,800	75	80	20%*	0.44	14.9	0.25	15.0	16.0
2	M	1.61	74	13,000	73	79	40%	0.64	29.6	0.49	29.3	31.4
4	H	2.22	96	26,700	73	79	20%	0.44	19.2	0.32	14.7	15.7
Totals:							100%	1.8	74	1.2	74	79

*Note that run 1 and 3 are equally average as part of the Low burn rate category

SECTION 11

CONCLUSION

This test demonstrates that this unit is an affected facility under the definition given in the regulation. The emission rate of 1.8 g/hr meets the EPA requirements for the Step 2 limits.

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

SECTION 12

PHOTOGRAPHS

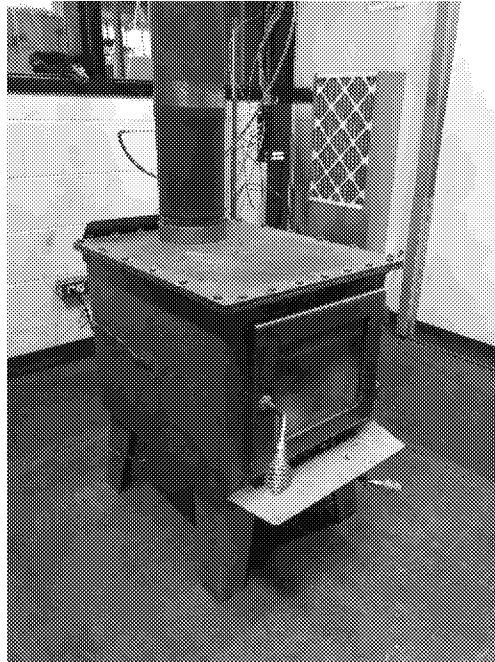


Figure 4 - Isometric view of unit



Figure 5 - Typical load



Total Quality. Assured.

8431 Murphy Drive
Middleton, WI 53562

Telephone: 608-836-4400
Facsimile: 608-831-9279
www.intertek.com/building

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

SECTION 13

REVISION LOG

REVISION #	DATE	PAGES	REVISION
0	12/22/20	N/A	Original Report Issue
		4	Table 1 was modified to add the fuel data.
		18	Section 9; statement was added to precise the height of the combustion chamber.
1	03/03/21	20	Added Table 3 - FUEL DATA SUMMARY

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

SECTION 14

APPENDIX - REPORT TABLES AS PER ASTM E3053-17

Table 10 - Section 1 - Model Identification

SECTION 1 – Model Identification	
Model Name(s)/Number(s)	1.4 Series
Manufacturer	Stove builder international inc.
Address 1	250 Rue Copenhagen
Address 2	Saint-Augustin-de-Desmaures
Appliance Category(s) (Free-standing, Insert, etc.)	Free-standing
Usable Firebox Volume - ft ³	1.55
Catalytic/Non-Cat	Non-Cat
Convection Air Fan (No, Standard, Optional)	Optional
SECTION 1B – Laboratory Information	
Testing Laboratory	Intertek testing services
Address 1	1829 32nd Avenue
Address 2	Lachine, QC H8T 3J1
ISO/Accreditation Info	ISO 17025
Dates Tested	11/17/2020 - 11/20/2020
Test Methods/Standards	CAS B415.1-10, ASTM E2515, ASTM E3053
Dilution Tunnel Inside Diameter - in.	8.00
Fliter Diameter - mm	47
Filter Material	Pall TX40

Table 11 - Section 2 - Test Conditions Summary

SECTION 2 – Test Conditions Summary				
Model Name(s)/Number(s)	1.4 Series			
Usable Firebox Volume - ft ³	1.55			
Convection Air Fan (No, Standard, Optional)	Optional			
Test Run #	1	2	3	4
Date Tested	2020-11-17	2020-11-18	2020-11-19	2020-11-20
Test Run Category (L, M, H)	L	M	L	H
Average Barometric Pressure - in Hg	29.52	29.98	29.88	29.68
Max. Observed Ambient Temp - °F	84	86	85	72
Min. Observed Ambient Temp - °F	70	74	69	68
Max. Observed Filter Temp - °F	85 & 86	87 & 86	86 & 86	87 & 87
Test Run Air Settings				

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Primary (measured up from minimum)	Min	1.625	Min	Max (3.625)
Secondary (measured up from minimum)	na	na	na	na
Convection Air Fan Setting	Off then L	Off then M	Off then L	Off then Max
Test Fuel Load				
Cordwood Fuel Species	Beech	Beech	Beech	Beech
Specific Gravity (from Table 1)	0.67	0.67	0.67	0.67
Higher Heating Value - Btu/lb (from Annex A1, ASTM E3053)	8088	8088	8088	8088
Nom. Test Fuel Load Piece Length - in.	16	16	16	16
Number of Test Fuel Pieces	5	5	5	4
Test Fuel Weight				
Kindling - As Fired lb	na	na	na	3.15
Kindling Wt. - As % of Test Fuel Load	na	na	na	20%
Kindling Moisture - % DB	na	na	na	10%
Kindling - kg DB	na	na	na	1.30
SU Fuel - As Fired lb	na	na	na	4.69
SU Fuel Wt. - As % of Test Fuel Load	na	na	na	29%
SU Fuel Moisture - % DB	na	na	na	21%
SU Fuel - kg DB	na	na	na	1.76
Test Fuel Load - As Fired lb	19.5	19.48	19.48	15.95
Ave. Test Fuel Load MC % DB	20.2%	19.5%	20.3%	19.8%
Test Fuel Load - kg DB	7.36	7.39	7.35	6.04
Test Fuel Loading Density - lb/ft ³	12.58	12.57	12.57	10.29
Residual SU Fuel Wt. - As Fired lb	na	na	na	1.6
Residual SU Fuel Wt. - As % of Test Fuel Load	na	na	na	10%
Test Run Duration - minutes	398.5	445.25	480	205
Test Run Duration - h	6.64	7.42	8.00	3.42
Test Fuel Load Wt. at End of Test - As Fired lb	0	0.09	0.08	1.44
Total Total Fuel Burned - kg DB	7.36	7.35	7.31	7.72
% Test Fuel Load Wt. at End of Test	0.0%	0.5%	0.4%	9.0%

Table 12 - Section 3 - Test Run Results Summary

SECTION 3 – Test Run Results Summary	
Model Name(s)/Number(s)	1.4 Series
Usable Firebox Volume - ft ³	1.55

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Convection Air Fan (No, Standard, Optional)	Optional			
Test Run #	1	2	3	4
Date Tested	11-17-20	11-18-20	11-19-20	11-20-20
Test Run Category	L	M	L	H
Burn Rate - kg/h DB	1.11	0.99	0.91	2.26
Burn Rate - As % of Low to High Midpoint	na	62%	na	na
Burn Duration - h	6.64	7.42	8.00	3.42
Heat Output - Btu/h	14818	12983	12124	26680
Dilution Tunnel Flow Rate - dscfm				
Average	335.13	337.36	332.25	323.90
Maximum Observed	343.73	357.44	353.55	338.34
Minimum Observed	321.74	312.39	311.67	309.63
Dilution Tunnel Temperature - °F				
Average	88	86	84	92
Maximum Observed	104	113	108	110
Minimum Observed	79	76	75	69
Sample Dryer Exit Max. Temp (or Max. DGM Temp) - °F				
Train 1	69	68	68	69
Train 2	69	68	68	69
Average Sample Flow Rates - dscfm				
Train 1	0.124	0.127	0.126	0.121
Train 2	0.125	0.128	0.128	0.122
Sample Vacuum - in. Hg				
Train 1				
Start	0.4	0.4	0.4	0.4
End	0.6	0.5	0.5	0.5
Maximum Observed	0.6	0.5	0.5	0.5
Train 2				
Start	0.4	0.4	0.4	0.4
End	0.6	0.5	0.4	0.4
Maximum Observed	0.6	0.5	0.5	0.5
Proportional Rate Variation (10-minute basis)				
# of Occurences > 5%, Total Both Trains	0	0	0	0
# of Occurences > 10%, Total Both Trains	0	0	0	0
Highest PR Variation - %, Either Train	103.5%	104.3%	104.2%	103.9%

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Total Sample Volume - dscm (m ³)				
Train 1	1.397	1.598	1.718	0.705
Train 2	1.414	1.615	1.740	0.709
Average Dilution Ratio				
Train 1	2707.0	2662.7	2628.6	2668.0
Train 2	2674.6	2633.6	2595.7	2652.7
Total PM Catch - mg				
Train 1	5.4	4.6	3.9	2.8
Train 2	5.5	4.4	3.6	2.9
Total Catch PM Weight Excluding Probe - mg				
Train 1 - Immediately Post-Test	5.0	3.2	3.0	2.5
Train 1 - Final Dry Weight	4.9	3.3	3.0	2.5
Train 2 - Immediately Post-Test	4.8	3.3	2.9	2.4
Train 2 - Final Dry Weight	4.9	3.4	2.9	2.5
Final Dry Probe PM Catch - mg				
Train 1	0.5	1.3	0.9	0.3
Train 2	0.6	1.0	0.7	0.4
Probe PM Catch as % of Total PM Catch				
Train 1	9.3%	28.3%	23.1%	10.7%
Train 2	10.9%	22.7%	19.4%	13.8%
Total PM Emissions - g				
Train 1	14.618	12.248	10.251	7.471
Train 2	14.710	11.588	9.345	7.693
Average	14.664	11.918	9.798	7.582
PM Emission Train Precision - %	0.3%	2.8%	4.6%	1.5%
PM Emission Train Precision - g/kg	0.01	0.09	0.12	0.03
PM Concentration - mg/m ³				
Train 1	3.87	2.88	2.27	3.97
Train 2	3.89	2.72	2.07	4.09
PM Emission Rate - g/h	2.21	1.61	1.22	2.22
PM Emission Rate - g/Mj (from CSA B415.1-10/15)	0.14	0.12	0.10	0.10
PM Emission Rate - lb/MMBtu (from CSA B415.1-10/15)	0.33	0.27	0.22	0.23
First Hour Emissions				
Sampling Duration (minutes)	60.00	60.00	60.00	60.00
Average Sample Flow Rate - dscfm	0.1178	0.1214	0.1208	0.1230
Total Sample Volume - dscm (m ³)	0.200	0.206	0.205	0.209

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Average Dilution Tunnel Flow Rate - dscfm	328.53	315.04	316.71	322.69
Average Dilution Ratio	2788.9	2595.1	2621.8	2623.5
Total PM Catch - mg	3.8	3.5	2.6	1.7
PM Concentration - mg/m ³	18.98	16.97	12.67	8.13
Total PM Emissions - g	10.60	9.08	6.82	4.46
PM Emission Rate - g/h	10.60	9.08	6.82	4.46
Total CO Emissions - g (CSA B415.1-10/15)	493.0	548.0	425.0	256.0
CO Emissions Rate - g/h (CSA B415.1-10/15)	74.3	73.9	53.1	95.9
Test Duration w/o Cold Start (High Fire Only) - h	na	na	na	2.67
Overall Efficiency - CSA B415.1-10/15				
% HHV Basis	74.9	73.3	74.3	73.4
% LHV Basis	80.2	78.6	79.6	78.6

TEST REPORT FOR STOVE BUILDER INTERNATIONAL INC.

Report No.: 104473478MTL-001R1

Date: 03/03/21

Table 13 - Section 4 - Weighted Average Summary

SECTION 4 - Weighted Average Summary			
Model Name(s)/Number(s)	1.4 Series		
Usable Firebox Volume - ft ³	1.55		
Convection Air Fan (No, Standard, Optional)	Optional		
Average for Each Test Run Category	L	M	H
Burn Rate - kg/h DB	0.91	0.99	2.26
PM Emission Rate - g/h	1.72	1.61	2.22
CO Emissions Rate - g/h	63.7	73.9	95.9
Overall Efficiency - CSA B415.1-10			
% HHV Basis	75	73	73
% LHV Basis	80	79	79
Heat Output - Btu/h	12100	13000	26700
Category Weighting	40%	40%	20%
ASTM E3053 Weighted Averages			
PM Emission Rate - g/h	1.8		
CO Emissions Rate - g/h	74		
CO Emissions Rate - g/min	1.2		
Overall Efficiency - CSA B415.1-10			
% HHV Basis	74		
% LHV Basis	79		
Heat Output Range - Btu/h	12100	to	26700

Note : In Table 13, the burn rate and heat output of the low burn rate are presented are the lowest obtained value to show the possible maximum range of performance. All other values of the low burn rate in table 5 are averaged between the two low burn rate test runs.